MUNICIPAL WATER SUPPLY FROM JAGERSFONTEIN MINE, ORANGE FREE STATE

by

T.S. KOK AND B.L. VENTER

Division of Geohydrology, Department of Environment Affairs, Pretoria

ABSTRACT

At Jagersfontein, groundwater is abstracted from an abandoned diamond mine from a depth of 220m (rest water level approximately 183m) at a rate of 17,5 ℓ/s in order to alleviate shortages in water supply from boreholes with yields of 4 ℓ/s tapping secondary fractures in the contact zones of Beaufort shale and dolerite intrusions. It is estimated that annual recharge to the mine amounts to approximately 264 000m³.

Analyses of groundwaters indicate that water from a spring near the mine is recently recharged, whilst the water from the mine is older, having been resident underground for a longer period since the time of infiltration.

CONTENTS

I. INTRODUCTION

Jagersfontein is situated approximately 110 km South-west of Bloemfontein, and the surrounding area is drained northwards by a tributary of the Riet River (Fig. 1).

At least 5 Kimberlite pipes occur in the area, one of which, located on the Townlands, has been mined since 1871 by various Mining Groups and individuals. In 1944, De Beers Consolidated Mines took over the lease of the mine, and mining continued down to a depth of approximately 750m. In order to keep the water level below this depth, some 64 000m^3/month were abstracted at a continuous rate of 26 ℓ/s.

Due to a decrease in the grade of diamonds with depth, the mine was eventually closed down in 1971, and in 1980 the Company gave permission to the Town Council of Jagersfontein to abstract water from the mine for municipal supply and

consumption.

II. GEOHYDROLOGY

The geology of the area surrounding the town consists of shales of the Adelaide Subgroup of the Beaufort Group (SACS, 1980). These shales are intruded by numerous dolerite sills and dykes. The occurrence of Kimberlite pipes has already been mentioned. It is interesting to note that the Kimberlite pipe on the Townlands, i.e. the intrusion under discussion, must have "blasted" its way through 180m of dolerite (Fig. 3). A vertical exploration borehole in the mine penetrated granite at a depth of 1019m from the surface (De Beers Consolidated, 1969).

The contact zones between the shales and dolerite intrusions usually exhibit fracturing, and yields in the order of 4 ℓ/s can be obtained from boreholes tapping these zones (Venter, 1979). The adjoining shales, however, have low transmissivities (50-100m^2/d) and low storage coefficients (1×10^{-4}). The abstraction of water for municipal supply from such boreholes during below average rainfall years (average annual rainfall equals 425mm) results in yields diminishing to such an extent, that water has to be rationed. This occurred regularly at Jagersfontein before abstraction from the mine was introduced. However, automatic water-level records indicate that the water levels in such dewatered boreholes recover rapidly in the wake of rainfalls in excess of 25mm (Kok, 1975).

III. ABSTRACTION

The town has a population of 800 Whtes and 3300 Blacks. The average water consumption amounts to approximately 800m³/day if and when rationing is not applied.

During the period 1971 to 1980, the water level in the abandoned mine rose to approximately 183m from the surface, and it was decided to pump from a depth of 220m from the surface, using the shaft, and thus allowing for a possible water-level drawdown of the order of 37m at an abstraction rate of 17,5 ℓ/d.

The data in Table I and Figure 4 indicates that the duration of pumping varied between 218 and 560 hours per month, with abstractions of between 14000 and 36000m³ per month, and resulting in a monthly drawdown of water level varying between 4 and 66cm, depending on the time of the year and the amount of precipitation.

TABLE I

Water-level fluctuations, monthly rainfalla and quantities abstracted at Jagersfontein mine.

Month	Waterlevel (m)	Rainfall (mm)	Duration of pump= ing (hrs)	Quantity abstracted (m^3)
Aug.	183,12	29	243	15369
Sept.	183,16	26	218	13732
Oct.	183,21	7	451	28150
Nov.	183,58	65	454	28090
Dec.	183,64	33	471	29144
Jan. 81	183,76	80	600	36528
Feb.	183,74	82	287	17372
March	183,20	134	421	25475
April	183,31	14	379	22882
May	183,29	64	372	22937
June	183,22	26	336	21007
July	183,35	0	383	25949
Aug.	182,69	121	313	21177
Sept.	183,20	0	372	25041
Oct.	183,25	28	494	32488
Nov.	183,46	33	534	34853
Dec.	183,36	103	479	31332
Jan. 82	183,70	10	560	36174
Feb.	183,94	16	470	29608
Total	-	0,968	7837	497308

~~March~~
May 82 184,30

IV. RECHARGE

Recovery of the water level after rain, and with some possible storm-water inflow, was as much as 54cm during March 1981, and 66cm during August 1981 (Table I and Fig.4).

Using the data in Table I, the annual groundwater inflow is calculated as follows:

Period under consideration:	1/8/80 to 28/2/82
Water-level drawdown:	183,94-183,12=0,82m
Rainfall:	968mm
Total water-level drawdown:	0,82+0,968=1,788m
Volume of water in 1,788min the mine with an area of 45220m^2:	45220x1,788=80853m^3
Quantity abstracted:	497308m^3
Groundwater inflow:	497308-80853=416455m^3
Inflow for 12 months:	$416455 \times \frac{19}{12}$ = 263828m^3
Average inflow per month:	approx. 22 000m^3

V. WATER CHEMISTRY

From the chemical analyses of water obtained from a borehole, a spring and the mine shaft (Nrs. 4, 3 and 2 respectively on Fig. 2), the percentage equivalents per million of the cations Ca, Mg and Na, and the anions Cl_2, SO_4 and HCO_3, have been plotted on a Piper trilinear diagram (Fig. 5).

Generally, the top half of the diamond contains static and other unusual waters high in $Mg/CaCl_2$ and $Ca/MgSO_4$.

TABLE II

Chemical composition of Jagersfontein groundwaters

Lab. Nr.	81411763			81411771			81411789		
Source	Shaft			Spring			Dairy		
Date sampled	290981			290981			390981		
Nr. on Fig. 5	(2)			(3)			(4)		
Ions	mg/ℓ	mE/ℓ	%	mg/ℓ	mE/ℓ	%	mg/ℓ	mE/ℓ	
NH_4^+	0,02			0,03			0,02		
NA^+	236,92	10,26		41,44	1,80		36,35	1,58	
K^+	9,15	0,23	78	1,57	0,04	18	1,38	0,04	15
Mg^{2+}	13,30	1,09	8	50,81	4,18	41	52,46	4,31	41
Ca^{2+}	37,60	1,88	14	84,89	4,24	41	92,74	4,63	44
Sum of cations	296,10	13,46	100	178,74	10,26	100	182,95	10,56	100
Cl^-	42,91	1,21	10	35,34	1,00	12	73,16	2,06	24
SO_4^{2-}	408,50	8,51	68	112,03	2,33	28	77,72	1,62	19
HCO_3^-	170,09	2,79	22	302,81	4,96	60	293,41	4,81	56
F^-	0,93	0,05	0	0,45	0,02	0	0,63	0,03	0
NO_3^-	0,67	0,01	0	1,25	0,02	0	4,16	0,07	1,0
Sum of anions	623,10	12,57	100	451,88	8,33	100	449,08	8,59	100
SiO_2	12,03			23,23			18,38		
P	0,02			0,01			0		
Sum of items	931,25			653,85			650,41		
pH	7,5			7,6			7,7		

The lower half contains those waters normally found in a dynamic groundwater environment (Johnson, 1975).

The position of sample Nrs. 3 and 4 on the diamond indicate that those waters are recently recharged. In contrast, the water from the mine shaft (Nr. 2 on the diamond in Figure 5) has been resident underground for a longer period, and can be classified as being on the border of dynamic underflow water and stagnant water.

VI. CONCLUSION

Groundwater in the mine at Jagersfontein is recharged at an estimated average annual rate of 264 000m^3. The water from a nearby spring and borehole is recently recharged, whilst that from the mine is much older.

ACKNOWLEDGMENT

We thank the Management of De Beers Consolidated Mines Ltd., Kimberley, for permission to use data from their report and maps

REFERENCES

De Beers Consolidated Mines Ltd. (1969). Jagersfontein Mine: Unpublished report.

Johnson, J.H. (1975). Hydrochemistry in groundwater exploration: SARCCUS Conf., Bulawayo.

Kok, T.S, (1975). Examples of groundwater-level fluctuations in the Republic of South Africa: Geol. Surv. S. Afr., Groundwater Series 1.

South African Committee for Stratigraphy, (1980). Stratigraphy of south Africa, Part 1 : Geol. Surv. S. Afr., Handbook 8.

Venter, B.L. (1979). Geohidrologiese ondersoek in die omgewing van Jagersfontein: Unpublished report Gh 3067, Div. of Geohydro., Pretoria.

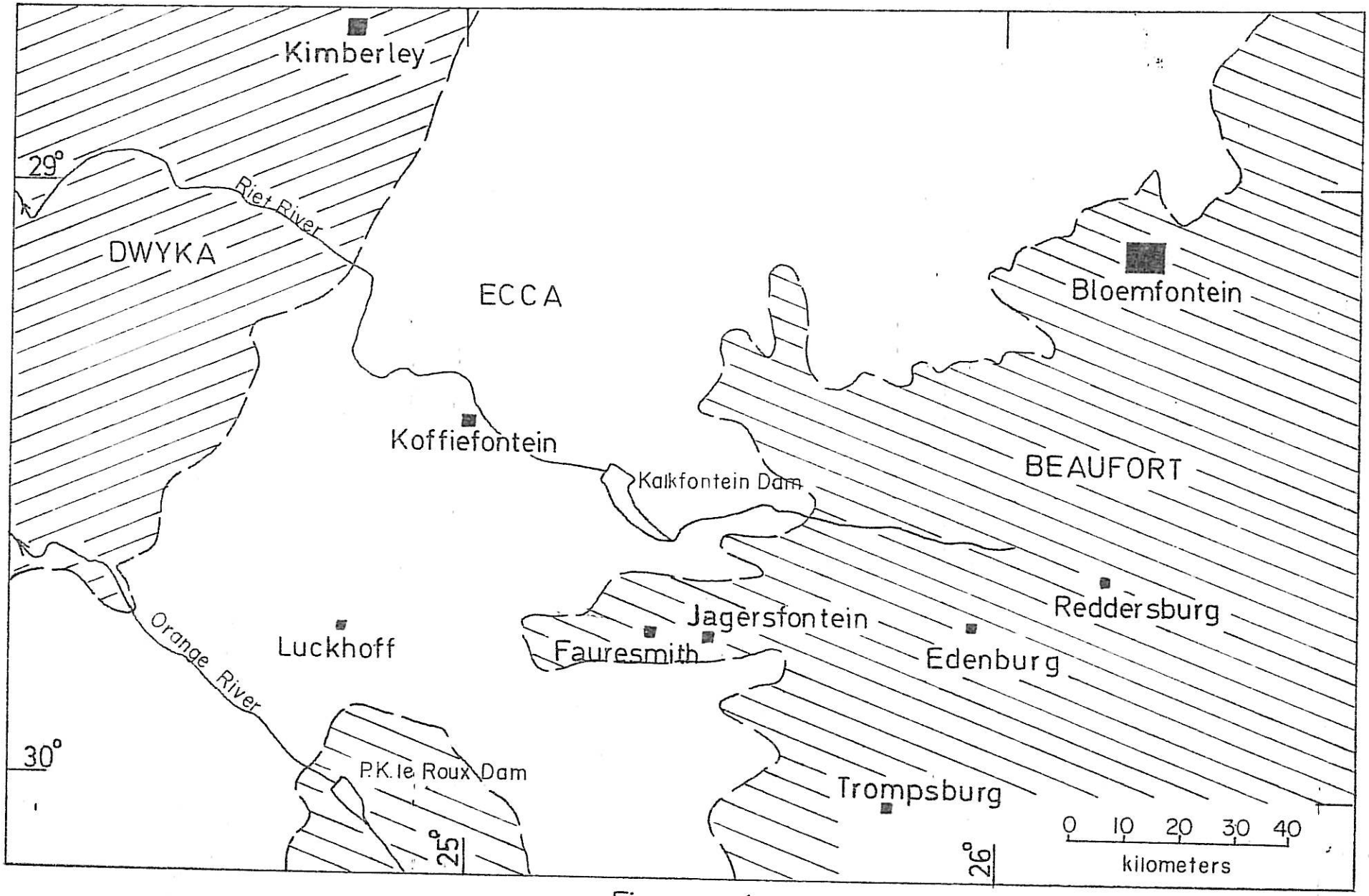

Figure 1

Location and general geology of Jagersfontein area

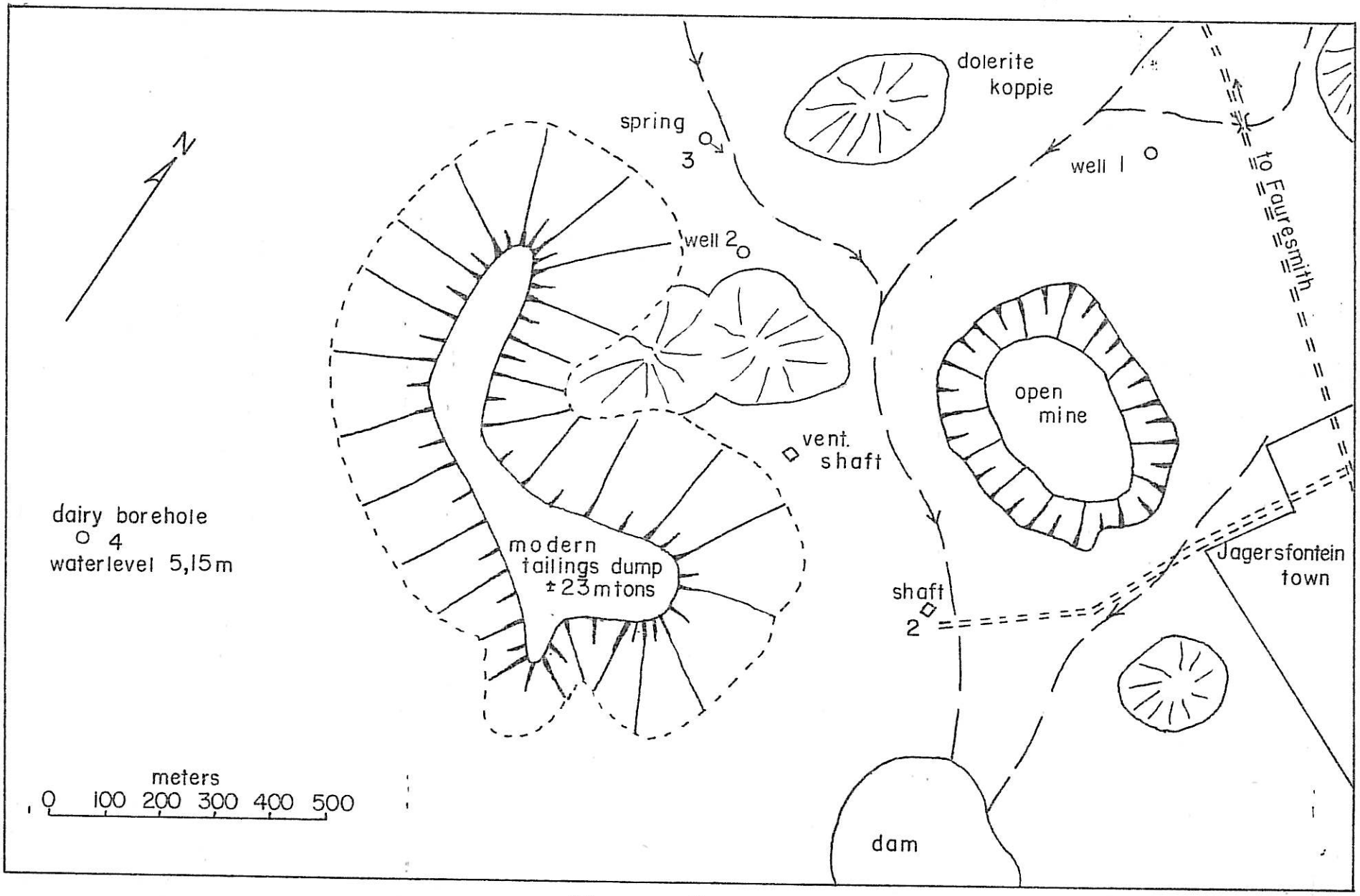

Figure 2

Locality plan of Jagersfontein mine area

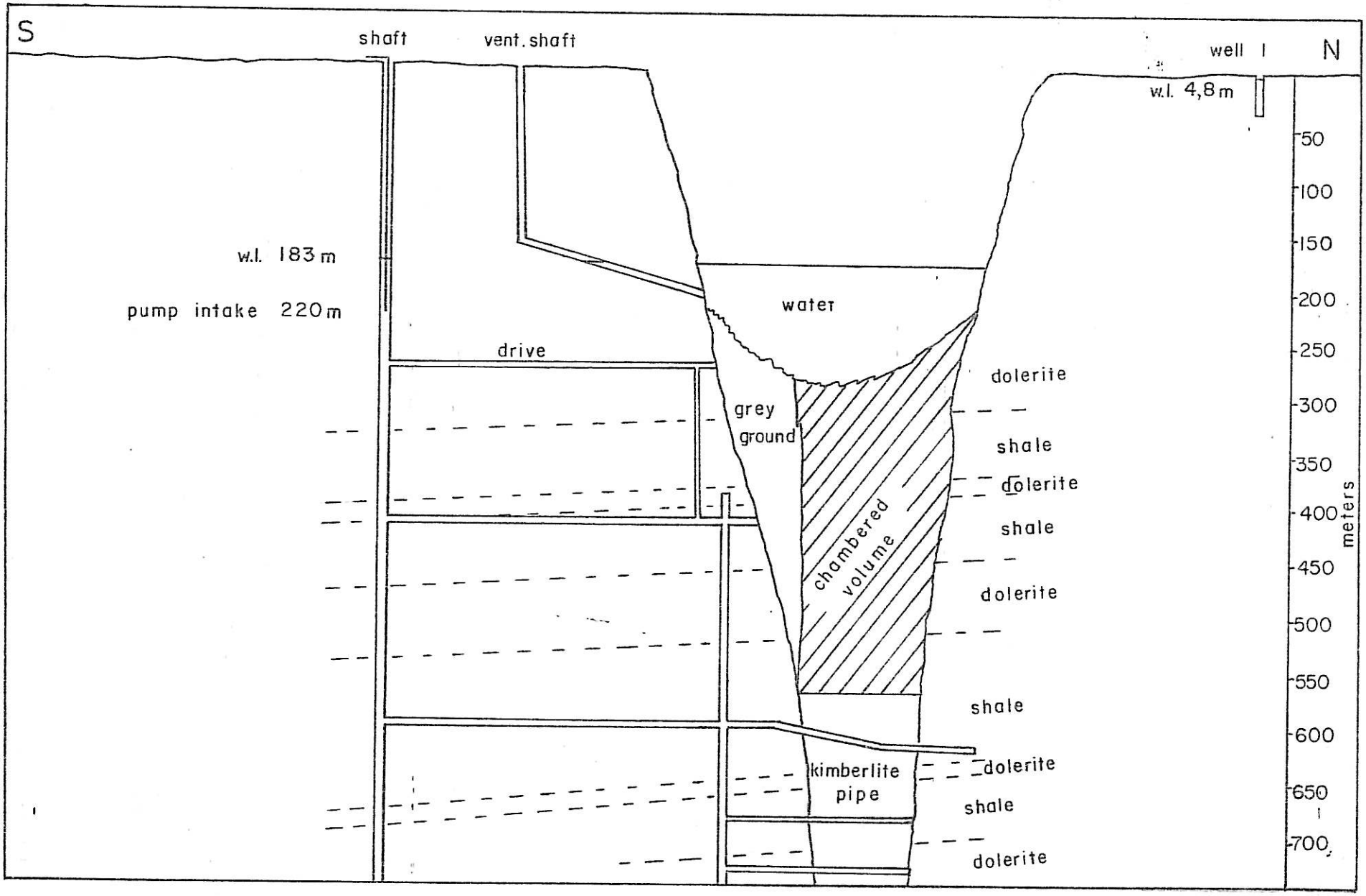

Figure 3

S–N section through Jagersfontein mine

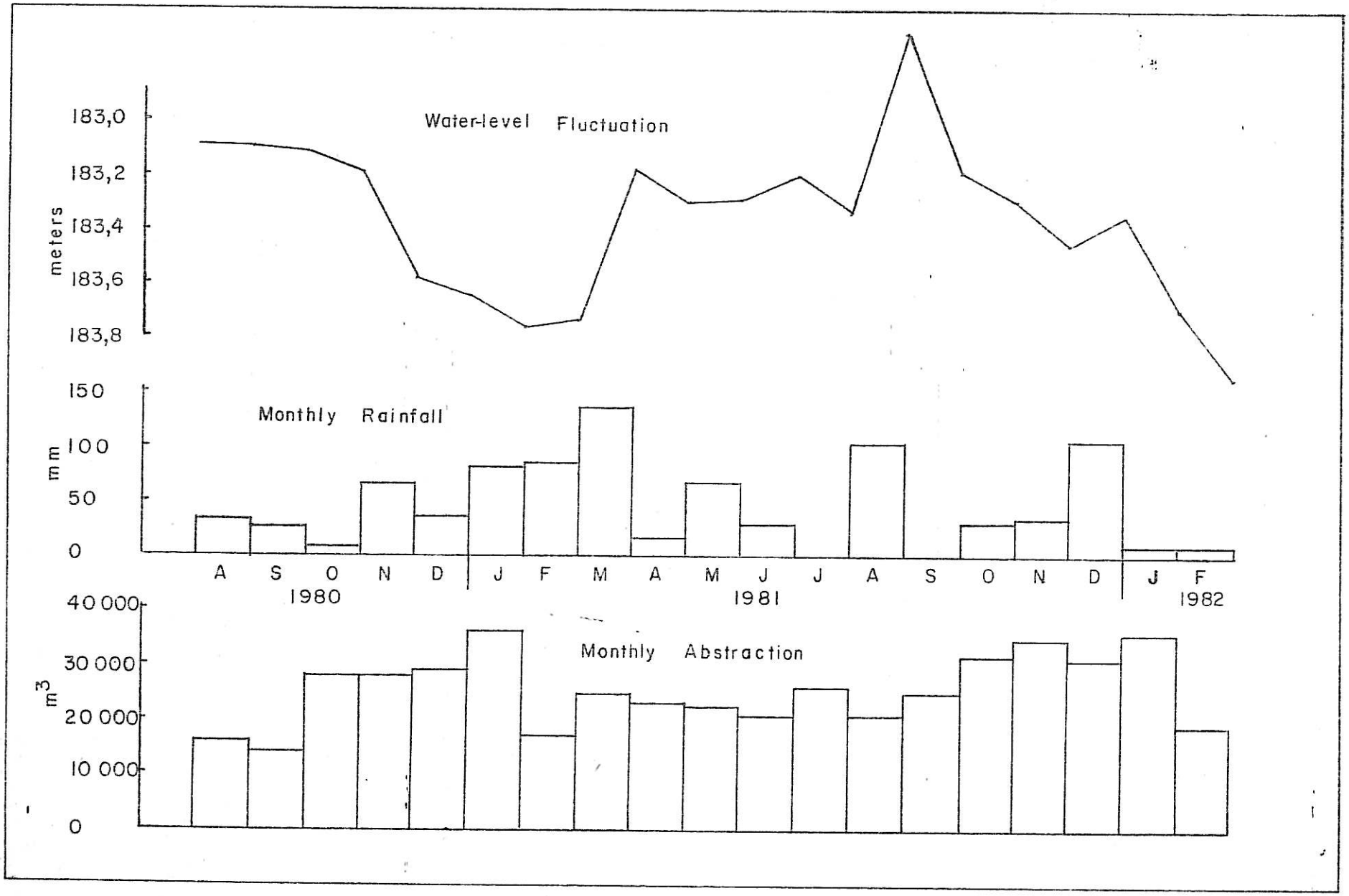
Water-level Fluctuation
183,0
183,2
183,4
183,6
183,8
meters
Monthly Rainfall
150
100
50
0
mm
A S O N D J F M A M J J A S O N D J F
1980
1981
1982
Monthly Abstraction
40 000
30 000
20 000
10 000
0
m3

Figure 4

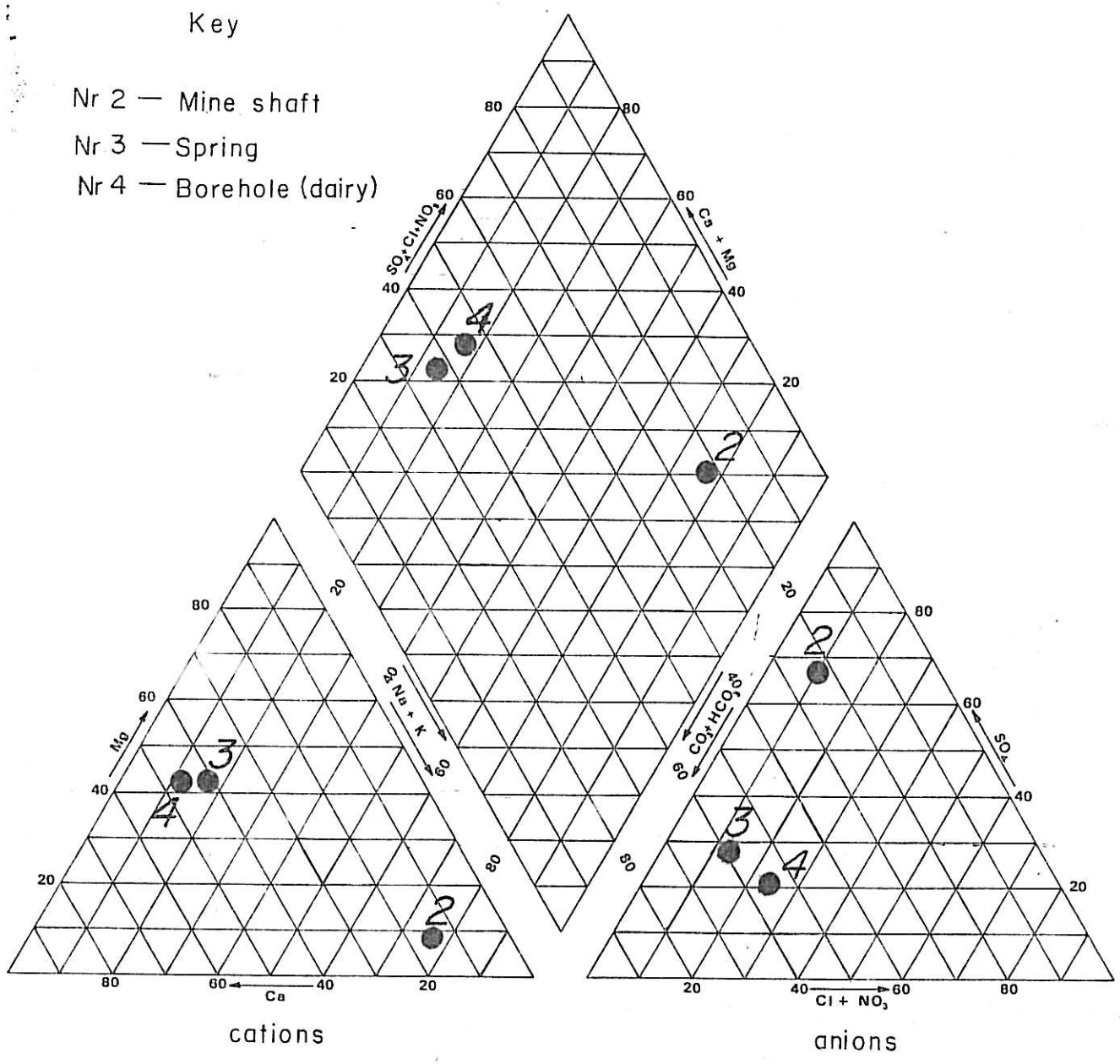

Figure 5

Trilinear Piper diagram of groundwater composition in the Jagersfontein mine area.